Good

UNCLASSIFIED

MOST Project – 4

1

LEVEL II

3355

AD A072451

TECHNICAL MEMORANDUM

U.S. NAVAL APPLIED SCIENCE LABORATORY
FLUSHING & WASHINGTON AVES.
BROOKLYN, NEW YORK 11251

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

Ap. 13

(9) Technical memo.

(1)

LEVEL II

(6)

DETERMINATION OF RELIABILITY OF EPOXY POTTING COMPOUND AND EUTECTIC METAL FOR TERMINATING THE ARMOR WIRE OF VARIABLE DEPTH SONAR TOWLINE SYSTEMS

(14) NASL-

Lab. Project 9400-97-TM-10

Technical Memorandum #10

Sub-Project No. S2720, Task 11309

(11) 14 JUL 1966

(12) 21p.

(10) V. Colletti

J. Macco

MATERIAL SCIENCES DIVISION

Approved: E. A. Imbembo

E. A. IMBEMBO

Acting Associate Technical Director

U.S. NAVAL APPLIED SCIENCE LABORATORY

FLUSHING AND WASHINGTON AVENUES

BROOKLYN, NEW YORK 11251

247550

75

Lab. Project 9400-97
Technical Memorandum #10

SUMMARY

Mechanical methods currently in use for terminating the armor wire of Variable Depth Sonar (VDS) towcables have proven unreliable. NASL undertook the development of a poured socket as a means of effecting a more suitable termination. As part of this work, NASL developed a rigid epoxy compound, designated NASL-E-4, consisting of an epoxy resin, a curing agent and a filler material in sufficient amounts to inhibit cracking due to the severe operating requirements of VDS systems.

NASL-E-4 epoxy compound and a low temperature melting eutectic metal (Cerro-Tru) were evaluated as socketing materials. Results of the work, conducted using SQA-10 VDS towcables, showed that a poured socket using the NASL-E-4 epoxy compound developed the full strength of the cable whereas the eutectic metal developed no greater than about 75% of the strength of the cable.

ADMINISTRATIVE INFORMATION

Ref: (a) NASL Program Summary, Sub-Project No. S2720, Task 11309 of 1 May 1966
(b) NASL Project 9400-53, Technical Memorandum #7 of 20 January 1965
(c) NASL Project 9400-97, Technical Memorandum #5 of 10 August 1965
(d) NASL Project 9400-96, Technical Memorandum #3 of 17 February 1966

TABLE: 1. Performance of SQA-10 Cable Terminating Materials Under Service Simulating Test Conditions

FIGURES: 1. Photo No. L-21054-1, Pouring of NASL-E-4 Epoxy Potting Compound in Socket of VDS Cable
2. Photo No. L-21054-2, SQA-10 Cable With Poured Sockets Shown in Thermal Shock Conditioning Oven
3. Photo No. L-21054-3, Poured Sockets of SQA-10 Cable Shown Submerged in Thermal Shock Cold Bath
4. Photo No. L-21054-4, Chamber in Which Poured Sockets of SQA-10 Cable Were Pressure Tested
5. Photo No. L-21054-5, Freezing of Poured Socket of SQA-10 Cable After Pressure Tests
6. Photo No. L-21054-6, Instrumentation Used to Maintain Elevated Temperature During Extremes of Temperature Test
7. Photo No. L-21054-7, SQA-10 Cable With Poured Epoxy Sockets After Tensile Test
8. Photo No. L-21054-8, Eutectic Socket of SQA-10 Cable Showing Pull-Out of Cable During Tensile Test (Pressure Conditioned)
9. Photo No. L-21054-9, Eutectic Socket of SQA-10 Cable Showing Shearing of Eutectic During Tensile Test (Thermal Shock Conditioned)

APPENDIX: A. Description of Socketing Materials and Socketing Procedures

1. As described in reference (a), the U.S. Naval Applied Science Laboratory is conducting research and development of components and materials to improve the performance and reliability of Variable Depth Sonar Systems. The work described in this report was conducted by the Dielectrics Group of the Plastics and Elastomers Branch

under the general supervision of Mr. C. K. Chatten, Branch Head and by the Mechanics Branch under the general supervision of Mr. H. V. Cordiano, Branch Head.

BACKGROUND

2. Mechanical type terminations now in use on VDS towlines are expensive, require elaborate machining and the use of special tools for forming the armor wire. Furthermore, the quality of a mechanical termination depends, to a large degree, on workmanship. There is also some question as to the reliability of the mechanical type termination as there has been a high incidence of "fish" loss attributable, in some cases, to failure of the termination. For the cited reasons, the Laboratory has undertaken the development of a poured socket termination using either epoxy potting compound or eutectic metal to replace the mechanical socket currently in use.

3. As part of this work, NASL developed a rigid epoxy compound, designated NASL-E-4, consisting of the ingredients shown in the following table.

EPON 828 Epoxy Resin	Condensation product of bisphenol A and epichlorohydrin	100 parts by weight
Diethylaminopropylamine	An amine curing agent which promotes cure at room temperatures	8 parts by weight
325 Mesh Tabula T61 Alumina	Filler material added to increase adhesion and to inhibit cracking	200 parts by weight

4. References (b) and (c) describe the results of single wire tensile tests evaluating various epoxy socketing materials, including NASL-E-4, and various preparation methods. This work indicated that the NASL-E-4 epoxy compound using sandblasting as a surface preparation was most suited for the intended application. Tensile tests on SQA-10 and SQA-13 (old) towcables, using NASL-E-4 epoxy terminations, showed that the poured epoxy socket developed 100% of the towcable strength.

5. Single wire tensile tests were also conducted on Corro-Tru eutectic metal with satisfactory results, indicating that further investigation of the material was justified.

OBJECT

6. The objective of this work is to determine the reliability of epoxy potting compounds and eutectic metal as socketing materials for use in VDS towline system applications.

PROCEDURE

7. As described in paras. 4 & 5, the epoxy compound, NASL-E-4, and the Cerro-Tru eutectic alloy have sufficient holding strength in an "as cast" condition to provide possible application as socketing materials for VDS towlines. To determine reliability of the materials, further work was conducted which was designed to simulate service conditions.

8. To this end, six lengths of SQA-10 cable were terminated, three with NASL-E-4 compound and three with Cerro-Tru alloy. The socket used was of the open spelter type, 1-3/8" - 2-5/8" in diameter by 5-1/2" long. Pertinent information regarding the socketing materials, and the techniques used in applying the materials is contained in Appendix A. Pouring of an epoxy socket is shown in Figure 1. Two cables, one of each type, were subjected to the following test conditions:

a. Thermal Shock and Heat Endurance - The cables were heat aged in a gravity type oven (see Figure 2) maintained at 158°F for a period of 700 hours. The cables were removed from the oven at intervals of 24 to 72 hours, a total of 20 times, and the sockets submerged each time for 10 minutes in a water and dry ice bath (see Figure 3) maintained at 39°F. The sockets were inspected visually after both removal from the oven and from water bath for evidence of material cracking. After completion of the evaluation, tensile tests were conducted on the cables at 77°F to determine the performance of the socketing materials.

b. Hydrostatic Pressure - The cables were immersed in water at 500 psi pressure for a period of 700 hours. Figure 4 shows the chamber which was used. The pressure was then cycled 100 times from 0 - 500 psi, the time for each cycle being approximately one-half minute. After pressure cycling, the sockets were removed from the chamber and inspected visually for evidence of material cracking. The sockets were then submerged for two hours in an alcohol and dry ice bath (see Figure 5) maintained at 23°F to freeze the water that may have been absorbed during pressure exposure, and the sockets were again inspected for material cracking due to water expansion. Tensile tests were then conducted on the cables at 77°F to determine the performance of the socketing materials.

c. Extremes of Temperature - Tensile tests were conducted on the cables with the sockets held at the operating temperatures of VDS towlines. The socketing material on one end of the cable was maintained at a temperature of 158 F by means of a thermostatically controlled heating mantle placed around the socket. Figure 6 shows the heating mantle and the instrumentation used. The socket on the opposite end of the cable was fitted with a polyethylene bag containing dry ice. A thermocouple embedded in the material was used to measure temperature. The tensile test was started when the material reached a temperature of -20 F. This temperature was maintained during the test.

RESULTS

9. Results of tests are contained in Table 1. Figures 7 through 9 show the effects of tensile tests on cables and conditioned sockets.

CONCLUSIONS

10. Results of tests showed the following:

a. A poured socket is a practical and reliable method of terminating the armor wire of VDS towline systems.

b. The NASL-E-4 developed epoxy potting compound possesses the required properties for terminating the armor wire of SQA-10 VDS towline systems.

c. The Cerro-Tru eutectic metal is unsatisfactory for terminating the armor wire of SQA-10 VDS towline systems because of insufficient strength.

ADDITIONAL STUDIES

11. The following supplementary work has been conducted using the NASL developed epoxy socket:

a. A 1-5/8" locked coil wire rope was socketed on one end with a commercially developed wire rope potting compound and the other end was socketed with the NASL-E-4 material. Tensile test was then conducted on the rope with the result that both socketing materials held and the rope was broken at a load of 343,000 pounds. However, the commercial material was found to be cracked and a portion of it had been pulled out of the socket. NASL-E-4 exhibited no deficiencies. Complete results of this work are contained in reference (d).

b. Three 3/4" titanium wire ropes were socketed with the NASL-E-4 material and tensile tests were conducted. The sockets maintained their integrity in all cases and the wire ropes were broken at an average load of approximately 44,800 pounds.

FUTURE WORK

12. As final evaluation of the reliability of the NASL poured epoxy socket, the following is planned:

a. Arrangements will be made with the Illinois Tool Works for trial installation of the poured socket on SQA-10 equipped ships.

b. Various lengths of SQA-13 cable will be epoxy socketed and the cables subjected to vibration and cyclic impact tests under a contract with the Preformed Line Products Company.

PHOTO L-21054-1

Figure 1 - Pouring of NASL-E-4 Epoxy Potting Compound in Socket of VDS Cable

U.S NAVAL APPLIED SCIENCE LABORATORY LAB. PROJECT 9400-97

PHOTO L-21054-2

Figure 2 - SQA-10 Cable With Poured Sockets Shown in Thermal Shock Conditioning Oven

PHOTO L-21054-3

Figure 3 - Poured Sockets of 3 A-10 Cable Shown Submerged in Thermal Shock Cold Bath

U.S NAVAL APPLIED SCIENCE LABORATORY LAB. PROJECT 9400-97

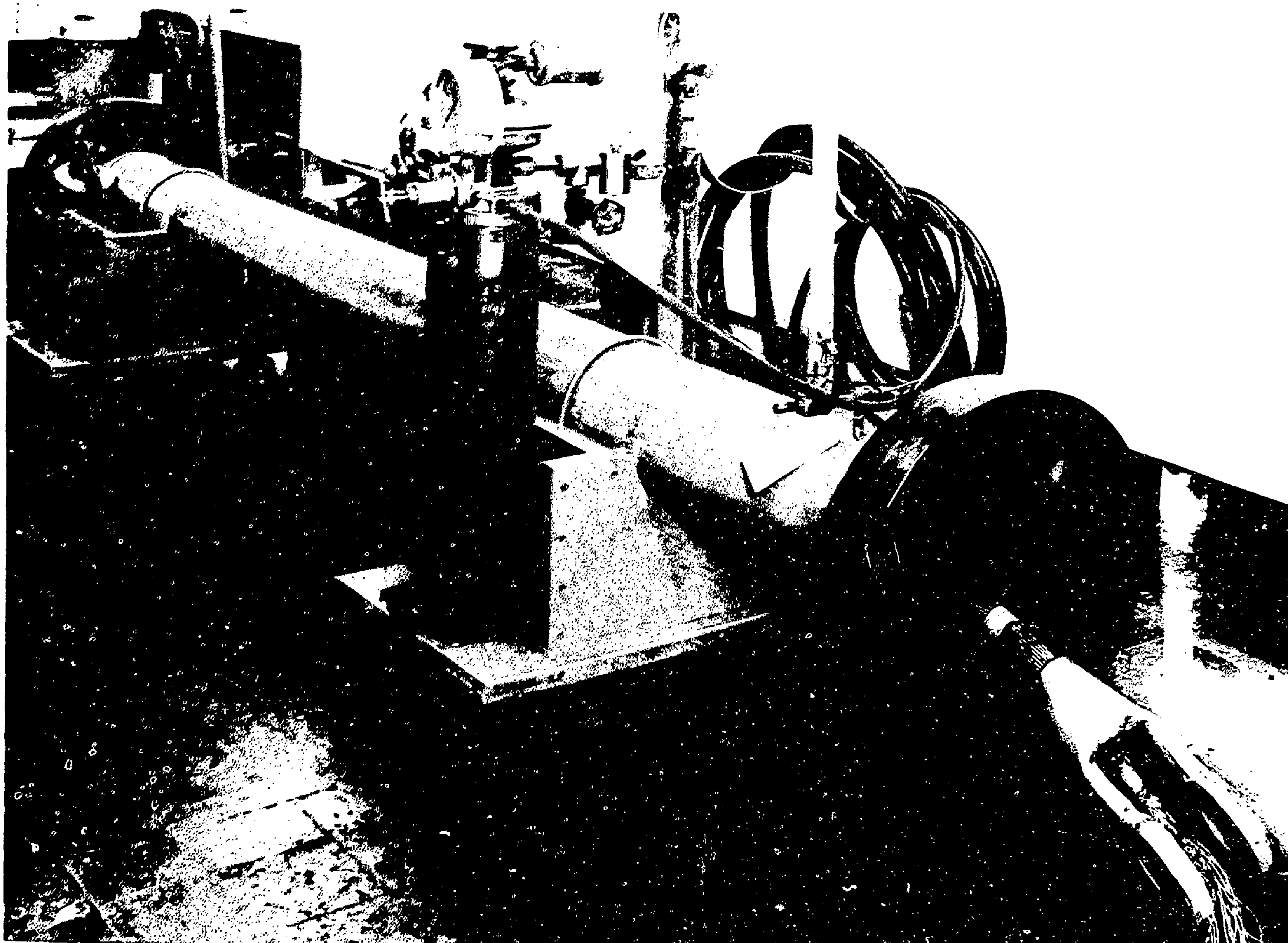

PHOTO L-21054-4

Figure 4 - Chamber in Which Poured Sockets of SQA-10 Cable Were Pressure Tested

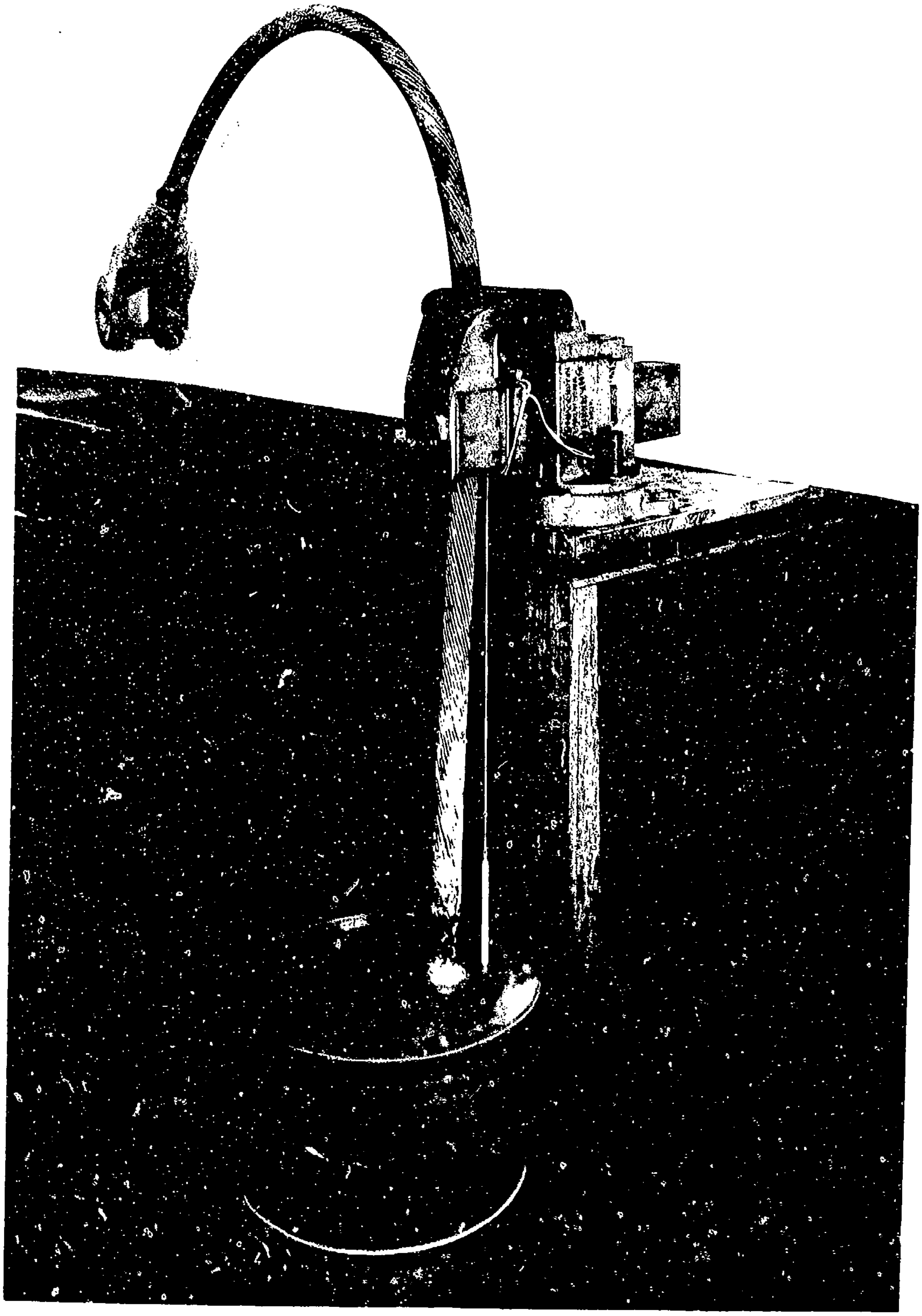

PHOTO L-21054-5

Figure 5 - Freezing of Poured Socket of SQA-10 Cable After Pressure Tests

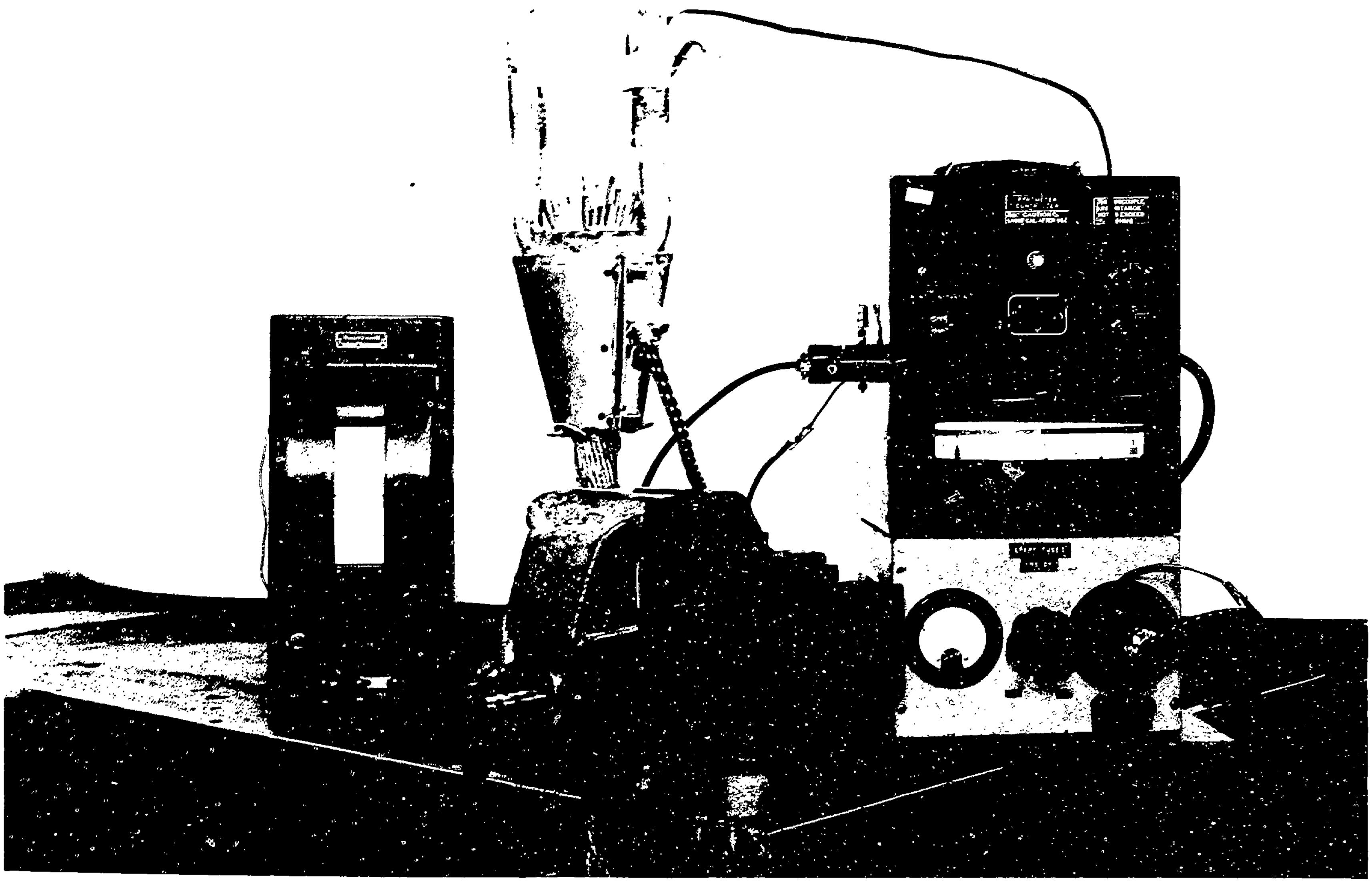

PHOTO L-21054-6

Figure 6 - Instrumentation Used to Maintain Elevated Temperature During Extremes of Temperature Test

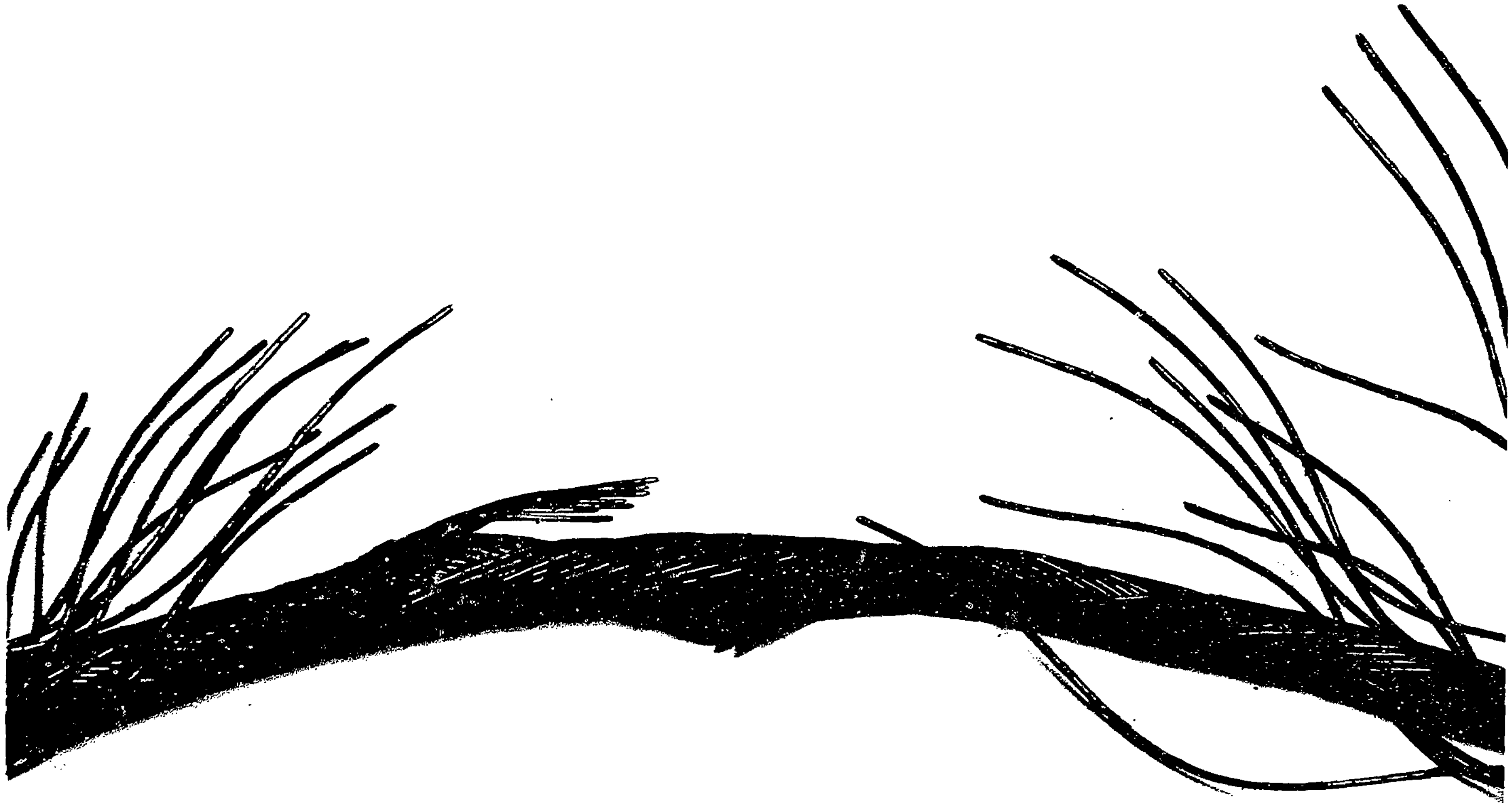

PHOTO L-21054-7

Figure 7 - 3&A-10 Cable With Poured Epoxy Sockets After Tensile Test

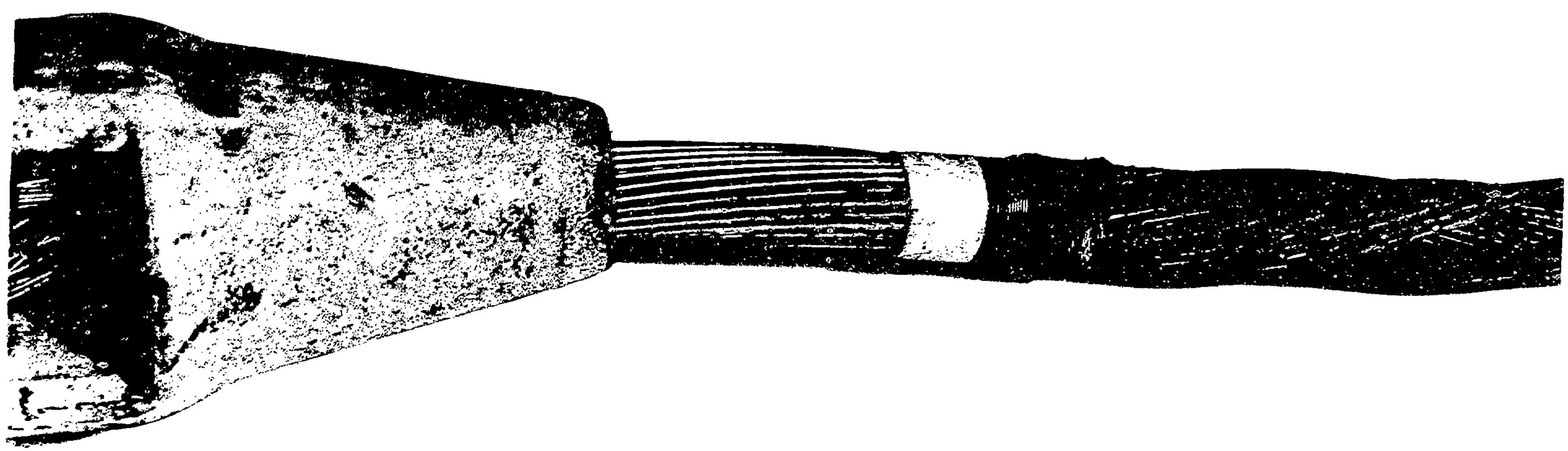

PHOTO L-21054-8

Figure 8 - Eutectic Socket of SQA-10 Cable Showing Pull-Out of Cable During Tensile Test (Pressure Conditioned)

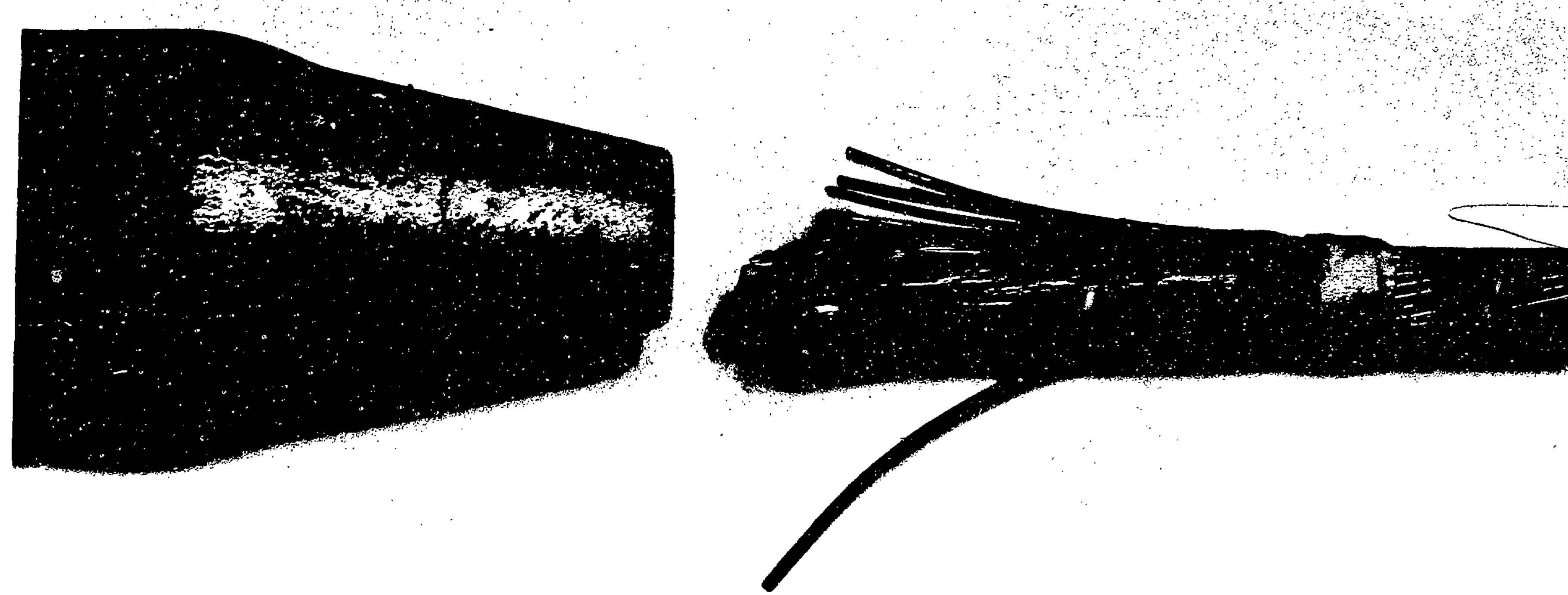

PHOTO L-21054-9

Figure 9 - Eutectic Socket of S A-10 Cable Showing Shearing of Eutectic During Tensile Test (Thermal Shock Conditioned)

TABLE 1

PERFORMANCE OF SQA-10 POURED SOCKETS UNDER SERVICE SIMULATING TEST CO

A. Thermal Shock and Heat Endurance(1)

	Socketing Materials	Condition of Socketing Material During Shock	Tensile Test of(4) Socketed SQA-10 Cable After Shock	
1.	NASL-E-4 Epoxy Potting Compound	No Cracking	Cable Break at 138,000 pounds	No cracki out of ma
2.	Cerro-Tru Eutectic Metal	No Cracking	Cable Pull-Out at 103,000 pounds	Cable pul layer of the wire.

B. Hydrostatic Pressure(2)

	Socketing Materials	Condition of Socketing Material: After Pressure Test	Condition of Socketing Material: After Freezing Socket	Tensile Test of(4) Socketed SQA-10 Cable After Pressure Test	
1.	NASL-E-4 Epoxy Potting Compound	No Cracking	No Cracking	Cable Break at 142,400 pounds	No cracki out of ma
2.	Cerro-Tru Eutectic Metal	No Cracking	No Cracking	Cable Pull-Out at 37,500 pounds	Wire pull Inspectio ing as so present o

C. Extremes of Temperature(3)

	Socketing Materials	Tensile Test of Socketed(4) SQA-10 Cable	Remarks
1.	NASL-E-4 Epoxy Potting Compound	Cable Break at 136,600 pounds	No cracking of material; no pull-o socket.
2.	Cerro-Tru Eutectic Metal	Cable Pull-Out at 82,000 pounds	Cable pulled out with thick layer the wire. Pull-out was at the ele socket.

Lab. Project 9400-97
Technical Memorandum #10

ST CONDITIONS

Remarks

cracking of material; no pull- of material from socket.

le pulled out with thick er of eutectic surrounding wire.

Remarks

cracking of material; no pull- of material from socket.

pulled out of eutectic. pection showed faulty socket- as soldering flux was still ent on wires.

ks

ull-out of material from

ayer of eutectic surrounding elevat temperature

NOTES: (1) 700 hours exposure at 158°F plus 20 cycles between 158°F and 39°F.
(2) 700 hours exposure at 500 psi plus 100 one-half minute cycles between 0 and 500 p
(3) One socket maintained at 158°F during test; the other maintained at -20°F.
(4) Nominal strength of SQA-10 cable is 122,000 pounds.

3

ing of material; no pull-out of material

psi ulled out with thick layer of eutectic surrounding
e. Pull-out was at the elevated temperature

°F and 39°F.
cycles between 0 and 500 psi.
maintained at -20°F.

4

APPENDIX A

DESCRIPTION OF SOCKETING MATERIALS AND SOCKETING PROCEDURES

1. Socketing Materials

Material	Ingredients	Manufacturer	Melting Temperature
a. NASL-E-4 Potting Compound	100 Parts Epon 828	Shell Chemical Company	Ingredients mixed at 77°F
	200 Parts 325 Mesh T61 Tabular Alumina	Aluminum Corp. of America	
	8 Parts Diethylaminopropylamine Curing Agent	Miller-Stephenson Chemical Company	
b. Cerro-Tru Eutectic Metal	Alloy of Tin and Bismuth	Cerro dePasco Company	282°F

2. Socketing Procedures

a. NASL-E-4 Potting Compound

(1) Sockets were placed on and secured to the cable with cord.

(2) Seizing wire was applied to the cable starting at a distance 5½' from each end of the cable.

(3) The cable ends were unravelled and fanned out down to the seizing wire, then the ends of the cable were thoroughly degreased with xylol.

APPENDIX A

DESCRIPTION OF SOCKETING MATERIALS AND SOCKETING PROCEDURES

(4) The ends of the cable were sandblasted at 100 psi air pressure using a 100-200 mesh particle.

(5) The sockets were pulled over the ends of the cable, then each socket, in turn, was set in an upright position in a vise.

(6) The material was prepared, poured in the socket, and cured for 16 hours at 77°F.

(7) The sockets were removed from the vises, then the compound was post cured in an air circulating oven for five hours at 122°F.

b. Cerro-Tru Eutectic Metal

(1) Sockets were placed on and secured to the cable with cord.

(2) Seizing wire was applied to the cable starting at a distance 5½" from each end of the cable.

(3) The cable ends were unravelled and fanned out down to the seizing wire, then the ends of the cable were thoroughly degreased with xylol.

(4) Soldering paste was brushed onto the wire on each end of the cable.

(5) The sockets were pulled over the ends of the cable, then each socket, in turn, was set in an upright position in a vise.

(6) The sockets were heated with an acetylene torch to a temperature of 200°F as measured with a contact thermometer.

(7) The material was brought to a temperature of 285°F, then poured in the respective sockets. The 285°F temperature is sufficient to vaporize the flux, and effect tinning of the cable wire by the eutectic.